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THE INSTITUTION OF CIVIL ENGINEERS.

The fifty-eighth annual meeting was held on Tuesday, the 21st of December, 1875, at the rooms of the society, 25 Great George street, Mr. Thomas E. Harrison, the President, in the chair.

In commencing the report, the Council congratulated the Institution upon a year of decided progress, not only in its home connections, but also, and especially, in its foreign relations, for since the last anniversary its cosmopolitan character had been more marked than ever.

During the past session fifteen papers, on nine subjects, had been read and discussed at the twenty-three ordinary meetings. The subjects related to railways, the water supply of English towns, the Indian system of water supply and of tanks, the manufacture of steel, gas works, the Chesil Bank, docks, breakwaters, and heavy guns. One hundred and seventeen persons had joined in the discussions, of whom ninety-one belonged to the Institution, and twenty-six were visitors. The average attendance at the meetings had been 227. The communications and the discussions upon them were recorded in four volumes of Minutes of Proceedings, issued to the members at intervals throughout the year, together containing 1,599 pages of printed matter, illustrated by thirty-nine plates and eighty-three wood cuts. The proceedings now also comprise other original essays deemed by the Council more suited for printing alone than for reading and discussion. These selected papers, fifteen in number, were of a very varied nature, in which engineering operations in Sweden, India, France, Canada, the United States, Holland, Russia, England, and Switzerland were represented. An entirely novel feature in the publications was the section devoted to "Abstracts of Papers in Foreign Transactions and Periodicals," which had involved much thought and labor on the part of the Council, whose anticipations as to their value had, however, been fully realized. The successive numbers of more than one hundred different periodicals had been regularly examined, and out of sixty-three of these periodicals articles had been selected, care being taken to obtain as great a variety as possible in all branches of engineering, and in allied experimental sciences. Among the sources of information there were 22 French, 12 Prussian, and 8 Austrian; Bavaria, America, and Italy contributed 3 each; Russia, Holland, and Belgium 2 each; India, Spain, Portugal, Saxony, Sweden, and Switzerland 1 each. The reception everywhere accorded to these extracts had been most flattering and encouraging. Communications had been entered into with the authors of the original articles, and with many other foreign engineers, from several of whom reprints of subsequent memoirs had been received, accompanied in some cases by carefully prepared abstracts.

As to membership, on the 30th November there were 14 honorary members, 826 members, and 1,449 associate members. The average increase for six years just past was 112, but for 1874–5 it was 160—the highest yet obtained. There are 328 students attached to the Institution.

The income proper for the year amounted to $40,000; he receipts from fees, etc., were $10,000, and from trust funds $2,300. The general expenditures had reached $24,500, and the cost of publications $15,500. The Institution had, altogether, in trust funds and investments a sum of $175,000, placed in government securities and guaranteed railway stocks.

In conclusion, it was remarked that during the time the Institute had been in existence the wealth of the world had been largely developed, mainly by the facilities of intercommunication by railways, harbors, and ocean steamships, by telegraphs, and by improvements in machinery, the work principally of civil engineers. These inventions had tended to promote personal intercourse between different nations, had fostered material and intellectual progress, and had increased the comfort and the welfare of all classes of society.

Premiums for original communications were awarded as follows: Telford medals and premiums to W. Hackney, B. Sec; H. E. Jones, A. R. Binnie, and G. F. Deacon; a Watt medal and the Manby premium to J. Clarke Hawkshaw, M. A.; and Telford premiums to Jules Gaudard, Professor Prestwich, F. R. S.; J. T. Smith, C. Colson, and T. C. Watson; also, the Miller prizes adjudged to A. E. Baldwin, J. C. Inglis, W. B. Myers, A. S. Moss, W. P. Orchard, J. Tysoe, and J. C. Mackay, students, for papers submitted by them.

The cordial thanks of the meeting were unanimously accorded to the President, Vice-Presidents, and other members of the Council, for their constant attendance at the meetings and their zealous efforts to promote the interests of the Institution. The thanks of the meeting were likewise given to Mr. Charles Manby, Honorary Secretary, and to Mr. James Forrest, the Secretary, for the very able manner in which they had performed the duties of their offices.

The following gentlemen were elected to fill the offices in the Council for the coming year: George Robert Stephenson, President; James Abernethy, Sir William George Armstrong, C. B., William Henry Barlow, and John Frederic Bateman, Vice-Presidents; Sir Joseph William Bazelgette, C. B., I. Lowthian Bell, M. P., Geo. Berkley, Frederick Joseph Bramwell, George Barclay Bruce, James Brunlees, Sir John Coode, Harrison Hayter, William Pole, C. William Siemens, Sir Joseph Whitworth, Bart., and Edward Woods, members; and Thomas Brassy, M. P., Douglas Galton, C. B., and Joseph Whitwell Pease, M. P., associates.

Notes.

Bar iron is selling at $56 a ton. In 1872 it was $112.

The Cambria Iron Company are putting their blast furnace at East Conemaugh in condition for making spiegeleisen, and it is expected it will go into blast in June.

Lorenzo M. Johnson, until recently Chief Engineer of the Keokuk and DesMoines Railway company, has been appointed Engineer, Paymaster and Assistant Accountant of that company.

A steam crane for doing the heavy lifting at railway stations, which is capable of moving itself from place to place along the track, has been put in operation in England, and is said to work well.

An effort is being made to secure the building of a branch of the Cleveland, Mount Vernon and Delaware Road from Millersburg, Ohio, south to Dresden, a distance of about twenty-five miles. Dresden is on the Pittsburg, Cincinnati and St. Louis Road.

The two Siemens furnaces being built up to replace two Bessemer furnaces, by the Cleveland Rolling-mill Company, are rapidly approaching completion, and it is expected to start them up on the 1st proximo. The remaining two Bessemer furnaces will be started up at the same time.

Arrangements are being made to build a new line from Lafayette, Ind., west to Templeton, nineteen miles, where the trains of the Cincinnati, Lafayette and Chicago Road now use the Lafayette, Muncie and Bloomington track. This section will be built by a new company, organized for that purpose, and the work will be pushed through as fast as possible.

The Board of Directors of the Wheeling and Lake Erie Road has voted to conclude a contract with Gen H. McKee to build the section of the road from Martin's Ferry, Ohio, to Zoar, about forty miles.

The proposed new bridge, the "Royal Albert," across the St. Lawrence at Montreal, is to be a stupendous affair. The length will be 15,500 feet; one span of 500 or 600 feet at a height of 130 feet above navigation; five of 300 each at the same height, four of 240 feet each, and 51 of 200 feet each. The estimated cost is $4,000,000, and the work may be completed in three years.

The anchor plates of the Hudson river bridge, of which there are four at each end, are cast iron and weigh twenty-three tons each. They were cast in Wilmington, Del. Fastened into each are sixteen radial arms, which form the first series of links of the chain that will connect the anchor plates with the cables. Each chain consists of ten sets of links, and two chains lead from each plate. The bars which constitute the links are 13½ feet in length, and vary in area of cross-section from 27 to 21 square inches. In each end of these bars is an aperture for pins, the largest being seven inches in diameter.

An ingenious little apparatus for assisting in mechanical drawing has been invented by a watchmaker in Chemnitz, Saxony. In machine drawing, projections, and the like, the drawing of dotted, half-dotted or stroke lines is a mechanical task, the wearisome features of which this apparatus is designed to relieve. An upright plate sliding on the paper, has on its lower edge a dented wheel catching in a bent lever which carries the pen point. A spring keeps the pen close to the paper. The wheel is kept in position by an adjustable plate. Wheels of various patterns can be used for producing a mixture of dots and strokes, the length and variations of which correspond to the indentations on the circumference of the wheel.

The following statistics of railway construction in the United States for the yeas 1875 is compiled from an elaborate review of the work for the year in the current issue of the *Railway Gazette*. The table gives the number of miles constructed in each State named for the year: Maine, 10; New Hampshire, 15½; Vermont, 32; Massachusetts, 34; Connecticut, 21; New York, 200; New Jersey, 72½; Pennsylvania, 118; Delaware, 5; Maryland, 17; North Carolina, 15; Georgia, 4; Texas, 34½; Arkansas, 38; Ohio, 7; Michigan, 30; Indiana, 106½; Illinois, 172; Wisconsin, 23; Iowa, 84½; Missouri, 27; Nebraska, 22; Colorado, 113½; Utah, 27, Nevada, 64; California, 174½. Making an aggregate of 1,483 miles for the year. In 1874 the total was 1,025; in 1873, 3,883, and in 1872, 7,340 miles.

Meetings are to be held to advocate the construction of a narrow-gauge road to run from Toledo, Ohio, westward through Morenci, Mich.; Fremont, Orland and Lima, in Indiana, to White Pigeon, Mich., to be called the Toledo, Paw Paw and South Haven Road, and running so far nearly parallel with and close to the southern boundary of Michigan, and about half way between the main and air lines of the Lake Shore and Michigan Southern. At White Pigion it is proposed to take a sharp bend and run north by west to Lawton, on the Michigan Central; then over the Paw Paw Road to Paw Paw, and thence northeast to South Haven, on Lake Michigan. The road would run through a country already well provided with railroads.

Relation of Sewer Grades to Zymotic Diseases.

BY GEO. W. RAFTER, ASSISTANT CITY ENGINEER, ROCHESTER, N. Y.

WRITTEN FOR ENGINEERING NEWS.

There is probably no question of the present day more pregnant with interest to every citizen of our large towns, than that of proper sewerage and drainage. Indeed, no question of the century has been more talked about, and is still less definitely settled, than this one. It is true, many suggestions have been offered, looking towards an improvement of sewerage and drainage systems, but as a general thing, few of them have been carried out; we are yet following the plan which our fathers followed, and are likely to follow it for several years to come.

In this present paper the author proposes to show, not so much new systems of sewerage and drainage, as the effect of old ones. In making such showing, we shall invite attention to the condition of sewers in the city of Rochester, assuming as an axiom that, whatever is true of the relation of sewerage aud drainage to the public health in any given loclity, is substantially true for all localities, proper allowance having been made for such differences as may be due to climate and water supply.

It is necessarv in the first place that we define our terms.

A sewerage system is a system of underground water channels by which refuse matter is carried away from our habitations, and disposed of in some way not offensive to human beings.

A drainage system is a system of underground water ways by which the surplus water is expeditiously carried out of the soil into natural water courses. The confounding of these two systems, which should always be separate and distinct, has been the cause of no little trouble and confusion, and. has in many cases been the source of serious evils to numerous large cities. As illustrating the last remark it may be cited, a twelve inch pipe having a grade of two inches to the hundred will carry drainage water, with little danger of stoppage from sediment, provided the supply is moderately constant. The same pipe, if called upon to carry the sewerage of say *ten* acres, would certainly fail, it will be necessary to increase the grade, otherWise our pipe, which answered every purpose when used as a drain only, fails completely, if used as a sewer without an increase of grade.

This introduces a consideration, of which more henceforth, that the grade of a sewer is more intimately related to the duty which the sewer is to perform, than might be inferred from the loose way in which they are frequently designed. Moreover, if the mere stoppage of the pipe, in the case just considered, were the only results, the damage would be comparatively slight, but following this comes a whole host of dangers. Zymotic disease extends its ravages on every side, and we find ourselves combatting a destructive agent, the evils of which half a generation may not completely abate.

Physicians are agreed that the class of diseases called zymotic are in the fullest sense of the word, preventable, prevnetable mainly, by a due attention to sewerage, drainage and water supply.

Now if zymotic disease depends for its prevention upon attention to the points just enumerated. it must follow that it is a *function* of those points, therefore, its prevalence indicates incompleteness in sewerage, drainage or water supply.

Let us attempt to trace the relation between zymotic disease, and sewerage and drainage only, in the city of Rochester.

Below are two tables which have been prepared to illustrate the point in question.

Table 1. shows the grade of the sewer, having the maximum grade in each ward, and its length; the grade of the sewer, having the minimum grade, and its length; the average grade of all the sewers in each ward; the number of lineal feet of stone sewer; the number of lineal feet of pipe sewer and the total number of feet of sewer in each ward; population of each ward; area of each ward in acres; number of square yards to each inhabitant; number of lineal feet of sewer to each inhabitant; average depth of sewers in each ward; number ot persons per acre in each ward; number of deaths from zymotic disease in each ward during six years, from January 1, 1870, to September 1, 1875; the ratio of population to deaths; and the number of persons to one death from zymotic disease.

TABLE 1

WARD.	Maximum Grade.	Length of Maximum Grade.	Minimum Grade.	Length of Minimum Grade.	Average Grade.	Number of feet of Stone Sewer.	Number of feet of Pipe Sewer.	Total number of feet of Sewer in Ward.	Population of Ward.	Area of Ward, Acres.	No. of square yards to each Inhabitant.	No. of lineal feet of Sewer to each inhabitant.	Average Depth of Sewers.	Average Sectional Area of Sewers in Square feet.	Number of Persons per Acre.	Deaths from Zymotic Diseases during six Years.	Ratio of population to Deaths.	No. of Persons to one Death from Zymotic Disease.
I.	1 403	800	0 320	915	0 976	14710	1869	16579	2965	85	173	7 01	9 35	5 88	28	35	0 0105	94 6
II.	2 400	750	0 160	370	0 750	1485	3148	4633	3478	135	187	4 55	2 72	3 97	26	49	0 0140	70 9
III.	2 209	400	0 200	1065	0 737	2180	2404	4584	2429	230	213	4 55	2 62	3 61	23	84	0 0166	69 3
IV.	2 000	660	0 111	1935	0 747	2180	1350	3530	5329	100	138	6 63	2 91	3 57	35	47	0 0170	74 3
V.	1 686	580	0 171	580	0 481	2264	13904	33500	6100	695	496	5 69	2 65	3 57	16	104	0 0135	58 6
VI.	1 444	960	0 211	1043	0 694	10185	6527	16712	3469	100	134	4 77	2 74	3 10	35	73	0 0184	54 3
VII.	3 360	1080	0 084	1280	0 514	9977	16935	26912	4007	310	374	6 90	3 91	3 20	13	56	0 0140	71 6
VIII.	3 000	666	0 117	1200	0 661	27035	8036	35071	7584	870	555	9 26	3 91	3 18	9	146	0 0092	51 9
IX.	2 433	960	0 141	3025	0 600	23588	11270	34717	6184	700	547	5 61	3 20	2 95	9	118	0 0190	52 4
X.	1 739	400	0 103	1425	0 613	15096	7461	23459	3000	310	415	5 50	2 96	2 67	11	54	0 0140	55 6
XI.	1 733	300	0 125	1867	0 625	30301	3443	32743	4474	335	379	7 65	2 96	3 57	13	137	0 0219	45 6
XII.	2 000	330	0 144	3911	0 553	16405	19187	35592	5220	335	279	6 72	2 95	3 57	15	207	0 0316	31 6
XIII.	1 600	667	0 136	1250	0 770	9970	5841	15511	2000	275	247	7 75	2 95	3 57	11	99	0 0219	45 6
XIV.	0 747	736	0 186	3590	0 394	13349	750	14099	4510	200	214	3 12	8 04	4 68	23			

NOTES.—Population taken at a mean between that of 1870 and 1875. N. B.—In the above table decimal places are indicated by spaces.
Average depth of Sewers for the whole city, 6.23.
Total number of deaths for the whole city, 1356.
Number of square yards per acre, 4840.

Table 2. taken from the Health Officer's report for the year ending April 1, 1875, shows the total number of deaths from all causes, in each ward, from April 1, 1872, to April 1, 1875; population of each ward; average yearly death rate per 1000 of population; miles of drainage in each ward, and area of ward in acres.

TABLE 2

WARD.	1872 to 1873. Male.	1872 to 1873. Female.	1872 to 1873. Total.	1873 to 1874. Male.	1873 to 1874. Female.	1873 to 1874. Total.	1874 to 1875. Male.	1874 to 1875. Female.	1874 to 1875. Total.	Total number of deaths in each Ward from April 1872, to April 1875.	Population of Wards.	Average yearly death rate for 1000 population.	Miles of Drainage or Sewerage.	Area of Wards in Acres.
I.	30	26	56	21	19	40	12	17	29	125	3314	13 4	3.14	85
II.	38	34	72	27	19	46	22	30	52	170	3986	17 22	3.58	135
III.	44	31	75	29	24	53	26	31	57	185	4363	16 98	4 04	230
IV.	46	31	77	32	26	58	26	36	62	197	4654	16 98	4 21	190
V.	57	40	97	53	47	100	39	34	73	270	6378	16 98	4 21	190
VI.	63	48	111	43	33	76	34	24	58	245	5778	16 98	4 56	925
VII.	49	40	89	39	37	76	35	24	59	224	5284	16 98	4 56	925
VIII.	42	40	82	45	40	85	30	25	55	222	5241	16 98	5 56	870
IX.	86	82	168	74	93	167	59	58	117	452	10667	16 98	5 56	870
X.	44	35	79	34	33	67	24	27	51	197	4654	16 98	4 56	870
XI.	64	57	121	55	45	100	24	27	51	272	6420	16 98	5 51	310
XII.	47	36	83	36	32	68	24	27	51	202	4770	16 98	5 51	310
XIII.	53	39	92	45	40	85	27	24	51	228	5384	16 98	4 58	550
XIV.	48	36	84	45	44	89	27	24	51	224	5288	16 98	1 88	200
TOTAL.	817	720	1537	645	644	1289	707	691	1398	4224	3991	17 59	1 88	200

NOTE.—Population of this table as per census of 1870.

It will be well to remark here that in Rochester the distinction between a sewer and a drain, above given, has been totally neglected; our sewers in every case performing the double function. Further, the fact that the city stands mainly on a rock foundation has influenced largely the mode of construction. The ordinary mode of construction being a square sewer with walls of stone from 18″ to 2′ thick, standing on the natural rock, and covered with flags, or in case of larger sewers, arched. The proportion of stone sewer of the kind just described, to pipe sewer is shown by Table 1. for each ward. In only a few cases are stone sewers constructed with artificial bottoms; it results, therefore, that the lime rock, filled with seams, is often found when these sewers are from any cause opened, to be completely saturated with sewerage matter of the most offensive description. From this same layer of lime stone the water supply of the city is at present mainly drawn. Moreover, it must be borne in mind that the figures in the table represent only the actual number of deaths from zymotic disease; they give no intimation of the far greater number of cases which were not fatal, but which have, nevertheless, left irremediable marks of their ravages on very many of the subjects of their devastation.

In order that accurate information might be given relative to the relation of fatal cases of zymotic disease, to those which are not fatal, Dr. E. V. Stoddard, Professor of Materia Medica and hygiene, of the University of Buffalo, an acknowledged authority on sanitary questions, to whom also the author is indebted for the number of deaths from zymotic disease, was consulted as to said relation. Dr. Stoddard furnished the following table of percentage of fatal cases in zymotic diseases:—

Cerebro Spinal Meningitis	.45
Scarlet Fever	.12
Typhoid Fever	.08
Dyptheria	.05
Cholera Infantum	.18
Cholera Morbus	.02
Diarrhœa	.01
Dysintery	.07
Average	11⅝ per cent.

Or, for even figures we may say that twelve per cent. of all cases of zymotic disease result fatally. At this rate we have 11300 cases for the time covered by the tables, or, during six years. About one in six of the whole population has been affected with some form of zymotic disease.

It will be well to notice at this point the general principle, that, however good the sewerage and drainage of a locality may be, there will always occur some cases of zymotic disease among the poorer classes, so long as their personal habits are not regulated, either by a restraining self-respect, or, that failing, by strict and efficient sanitary legislation.

The following notes on the peculiarities of the several wards will be found of assistance in studying the tables above given.

1st Ward, No. of deaths 25, distributed as follows: Front St. 8; Hill St. 6; Washington Sr. 3; West Main St. 4; Sophia St. 1; State St. 1; Exchange St. 1; Mill St. 1; No. of streets in the ward having permanent residents, 26. Front St. is directly on the river, and the people live in tenements of the poorest order. Every kind of refuse finds its way into the river from these tenements; and the real wonder is that there should be so few deaths, rather than so many. The sewer in Front St. is one of the best in the city being a tunnel, 9′×6′ for 500 feet, and the remainder of the distance of masonry. 4′×4′ arched; depth from 16′ to 20′; grade 1.31′ to the hundred to 2.4′ to the hundred; length, 1640′. This is the outlet of an area of 140 acres, and has a permanent sectional area of flow, of about 8′. This large permanent flow results from this sewer and its branches, taking the leakage of the Genesee River and the Erie Canal.

Hill St. is parallel to the Erie Canal and several feet below it. The sewer is one of the poorest in the city being of insufficient depth, and too low a grade; the cellars are therefore frequently flooded, not only by canal leakage but by storm waters.

West Main St. sewerage good, deaths mainly due to bad water and over crowding in tenements.

Washington St. aristocratic street of the ward, depth of sewer 12′, grade .326′ to the hundred, sewer of stone 2′×2′ with natural bottom, zymotic disease here propably due to imperfect house connections or bad water supply.

2nd Ward, There is only one point worthy of note in connection with this ward. Several of the more extensive stone sewers have artificial bottoms of brick. To this fact the comparatively low death rate of the ward is

undoubtedly due, as from the large proportion of stone sewer we might otherwise expect to find a larger death rate. The deaths are distributed quite equally over the whole ward, thus showing them due to general, and not to local causes.

3d Ward. The third ward is an excellent example of a large district naturally situated for superior sewerage, with comparatively poor sewerage. This ward is generally considered the best part of the city for residence, it being, with the exception of a small portion along the river front, wholly occupied for that purpose. The deaths in this ward are entirely among the wealthier classes, fourteen cases occurring on Plymouth avenue, the finest street in the city. The explanation is, that the sewers are mainly through the valleys, and are of low grade, while the residences stand on slight ridges. The low grade causes the retention of sewerage matter in the sewer, from which results the production of "sewer gas," the location of the houses above the sewers gives the "sewer gas" every opportunity to pursue its natural course upward to the houses; here water closets and the "modern improvements" generally give it still further opportunity for admittance. Once thoroughly inside its mission is chiefly to assist in producing zymotic disease.

The remainder of the wards have few peculiarities to especially mark them, their surface like that of the wards already considered, is quite uniform, there being neither great elevations nor great depressions. One or two of them however demand passing notice.

11th Ward. A reference to table 1, shows the sewers in this ward to be almost exclusively of the stone pattern before described. The population is mostly made up of the laboring classes. The "modern improvements" are not yet introduced into their houses. The death rate from zymotic diseases, as will be seen by again referring to the table, is the highest of any ward in the city.

This might indeed be inferred from the general condition of sewerage as shown by the tables, though uncleanly habits among the people have not been without influence.

A physician of repute concludes, however, after a careful survey of the ground, that, "the principal cause of zymotic disease in the eleventh ward is soil saturation and pollution of water supply by imperfect sewerage." The stone sewers of this ward are without artificial bottoms.

12th Ward. The location of this ward is such as to lead one naturally to expect a large proportion of zymotic disease, and, indeed, it was formerly the worst part of the city in that respect. In the last few years pipe sewers have been almost exclusively used in the twelfth ward, and with excellent results.

The death rate from zymotic disease, although high, is not so excessively so as in some wards where the natural facilities for thorough sewerage are much greater.

13th Ward. This ward has the smallest number of lineal feet of sewer to each inhabitant, of any ward in the city, and the death rate is the largest with the single exception of the eleventh. The inhabitants are mostly Germans, a very large proportion being laborers.

14th Ward. This ward has the lowest average grade of any in the city. The sewers are all trunk sewers, carrying large quantities of water continually; there is, therefore, little chance for deposits, hence the death rate is kept within fair limits.

As the result of the above to a certain extent cursory examination of the matter, the following conclusions may be drawn:

1. That there exists a definite relation between imperfect sewerage and zymotic disease; that as sewerage approaches perfection, zymotic disease decreases and conversely.

2. That the grade of a sewer should be a *true grade*, and as great as can possibly be attained.

3. That pipe sewers are vastly preferable to the old-fashioned, square-box, stone sewers, without artificial bottoms, still in use in Rochester and many other cities.

4. The sectional area of a sewer should be as small as is consistent with a due regard for the greatest amount of work it is likely to be called upon to perform.

5. Sewers should be deep enough to give a grade of at least three feet from the most remote house connection to the street.

6. In designing a system of sewerage two things are to be considered, average water supply, and average amount of sewerage matter to be disposed of, hence, we have the following general law: *The inclination or grade of a perfect sewer bears a definite relation to the to the average water supply, and to the amount of sewerage matter to be disposed of.*

Corollary 1. Other things being equal, the inclination should increase, as the amount of water to be regularly supplied decreases.

Corollary 2. For a given inclination, the water supply should increase in proportion to the increase of sewerage matter to be disposed of.

Corollary 3. For a given amount of sewage matter to be carried away, the inclination should increase as the water supply decreases.

Corollary 4. For a given water supply, the inclination should increase, as the sewage matter to be carried increases.

Corollary 5. The inclination may decrease as the water supply increases, sewage matter remaining constant.

Corollary 6. The inclination may decrease as sewage matter decreases, water supply remaining constant.

The determination of the necessary grades, and the minimum limits, will be considered at some future time.

In conclusion it may be remarked that the uniformity of natural surface-configuration throughout the whole city renders Rochester an excellent example for a comparison of the kind here attempted. There are no conditions of surface in one part of the city, which are not balanced by similar conditions in other parts.

These tables and statements are, therefore, given to the profession at large in the hope that other cities may be worked over in a similar manner. The method which is purely inductive is the true one, the tabulating of facts being, without doubt, the beginning of accurate knowledge on any subject whatever.

THE "DYNAGRAPH."

It is now some forty-five years since the railroad era fairly commenced in this country, and on many points connected with railway resistances we are yet groping in the dark from the want of formulæ deduced from practical experiments. Mr. P. H. Dudley, recently chief engineer on the Valley Road, and a gentleman who has devoted much study to matters of railroad economy during the past year, has brought into service a most valuable invention, known as the "Dynagraph." The object of the machine is to ascertain the resistances of engines, cars of different construction, and railway trains at all rates of speed upon the straight and curved portions of the track. Comparatively few experiments have been made in this country to ascertain the power absorbed in friction of the engines, cars, and trains in use. We have depended largely for information upon English and French experiments. Such information, to a great extent, must necessarily be unsatisfactory, for the good reason that the construction of the entire system of railways in those countries is materially different from our own. The conclusions to be drawn from the experiments of scientific engineers in Europe are not applicable to our roads.

It forms a large part of the expense of a railway to operate the motive power which is used to overcome the resistance due to heavy grades, sharp curvature, excessive weight of cars, different sized wheels and journals, kinds of brass and lubricants, condition of tracks, etc. The amount of force an engine exerts, for instance, in drawing a train is much less than is generally supposed, ranging, under ordinary circumstances, from 4,000 to 5,000 pounds. It is, therefore, quite obvious that it is important to reduce the resistance due to various causes to the lowest possible limit, with a reasonable cost of construction, the benefits of so doing not only accruing to the railway companies, but to the entire community, as thereby the cost of transportation may be cheapened.

Mr. Dudley has privately, and in a limited way, been operating with the "Dynagraph" for a month or two past, and the results have been such as to warrant the Lake Shore and Michigan Southern Railroad Company in offering him facilities to apply the most thorough tests of its practicability and utility. On Tuesday afternoon a train of forty-seven cars, with a caboose, in which the machine was operated, made the run from the Union Depot to Collinwood. The estimated weight of these cars, with their burden of freight, was about 948 tons. The cars comprised thirty-one of the White Line, fourteen of the Merchants' Dispatch, and two of the Empire Line. They were drawn by the locomotive "Jefferson," with six wheels connected; weight of drivers, 49,000 pounds; cylinders, 16x22; and the steam carried, 120 pressure. The portion of the road traversed was well adapted for a fair trial, being part of the way a thirteen foot grade, having several curves and a number of undulations, thus testing the capabilities of the machine in different ways. The train was a heavy one, and consisted of rather more loaded cars than it is expedient generally to attach to even as powerful a locomotive as the one employed. The speed at starting was at the rate of from three to four miles per hour, and increased to some ten or twelve miles per hour when over the heavy grade. It was gratifying to note the accuracy with which the machine indicated the rate of speed, the curves made, the power employed, and the oscillation of the cars. The engine, on the grade before mentioned, pulled 14,200 pounds and where the resistance was less but a few hundred.

The construction of the Dynagraph is as follows: Underneath the car is a steel cylinder, four inches internal diameter, filled with oil, in which a piston is fitted. The drawhead of the car is attached and draws on the piston, which forces the oil in the cylinder through a pipe to a small cylinder, in which is fitted a piston acting against springs of known tension. The crosshead of the small piston moves the levers which carry the pencil to mark on the paper the amount of force exerted. The paper used is what is known by engineers as continuous profile paper plate B, and is wound in lengths of 150 feet upon a drum, upon one side of the instrument, and passes through between two steel rollers over a little table about one foot square, through another set of steel rollers, then on to another drum, which winds up the paper as it passes through the rollers. The paper is moved by the steel rollers from direct motion of the car axle, each one-quarter of an inch of the paper representing one hundred feet upon the track. By a brush wheel, compensation can also be made for any increase or decrease of distance upon curves when found necessary. An armature, carrying a pencil making a straight mark, except at the end of seven and one-half seconds: the magnetic circuit is closed by a clock and the armature drawn back, indicating the distance traveled in the time mentioned. Consequently the speed for any given instant can be calculated, as it is necessary data in the case under consideration.

The instrument had to be constructed very strong to withstand the excessive shock due to unavoidable concussions in operating trains, yet at the same time made so that its adjustments are delicate. It was built by A. J. Johnson, one of Cleveland's mechanics, who not only designed many of the details, but carried them all out with great fidelity, and to whose excellent workmanship the success of the Dynagraph is largely due.

The Lake Shore Company propose to give Mr. Dudley every facility in their power to show the advantages to be derived from the "Dynagraph." The experiments are to be continued on different kinds of cars, and trial trips will be made over the entire Erie Division. It has already been ascertained that some of the cars in use pull a third harder than others.

On Thursday afternoon, at 2:30 o'clock, the railway officials of different roads will make a trip to Collinwood, and make a personal inspection of the machine, and examine its workings. We doubt not they will be pleased with the examination. Mr. Dudley certainly is in a fair way of greatly serving the public interests, and we wish him success in his laudable undertaking.—*Cleveland Herald.*

BRUNSWICK, MAINE, BOWDOIN COLLEGE.

EDITOR NEWS:—Can you tell me where I can get late and reliable information in regard to the variation of the magnetic needle in Michigan, or east of Lake Superior in Canada. Very Respectfully,

JAS. W. SEWALL.

January 17, 1876.

[Will any parties who have the desired information as above requested, please to communicate direct with Prof. Sewall. ED.

According to a French journal, the number of locomotives at present in use in the old and new worlds amounts to 50,000, representing a money value of 2½ milliard francs. In this number the United States figures with 14,200, England with 10,900. Germany with 5,900, France with 4,900, Russia with 2,600, Austria with 2,400, Hungary with 500, and Italy with 1200 engines.

ENGINEERING NEWS.

SATURDAY JANUARY 22th, 1876.

CEO. H. FROST, - Editor and Publisher.

168 Washington Street, Chicago, Illinois.

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CITY SEWERAGE.

In most of those cities of this country which have grown at a moderate rate the arrangement of the public sewers so as best to subserve all interests presents to the engineer a more than usually complex problem, when he is first called upon to reduce them to system. Some reasons for this statement we propose to give.

While the village is growing toward a town each landowner and householder provides for his own drainage. If the soil is gravelly, the inhabitants do without any drains beyond their own lots for some time, often for a number of years; if the soil is not so porous, or is clayey, the need of sewers will be sooner felt, but in these cases the contents of drains are often allowed to flow into the gutters, and are left to find their way, together with the surface water, wherever the natural inclination of the land may lead.

As a place becomes more thickly settled the evils of this way of getting rid of the sewage becomes manifest to the senses, if not immediately noticeable by its effect upon the health; and individuals of a neighborhood, uniting together, will construct a small drain, sufficient for their needs, often making it of wood, and, to save expense, putting it at the least depth thought sufficent for drainage and for protection from frost. In many cases such small drains or sewers will be turned over to the town authorities, on condition that those officers shall keep them in repair. This condition is usually a proper one, as drains, besides conducting off the rainfall speedily, tend to improve the condition of the streets by lowering the level of the water in the subsoil, and thus are a public benefit.

Such early improvements are made somewhat at random, and in those portions of the town most conveniently situated as regards water courses or gulleys, where the drains may empty. The lower parts of the town will be first sewered, as but short drains will be required, and these will be of small size. Sooner or later these sewers will be extended back, and lateral sewers will be joined to them.

The arrangements for further drainage will now probably pass from the hands of private individuals to those of the town officers. If the place fronts on a navigable river or arm of the sea, the demands of business cause the shore to become closely built over, and the buildings to increase in size. Their cellars are carried deeper, and the former sewers are too shoal to drain them. Then, again, as extensions are made, unless the land rises with moderate rapidity, some of the former outlets will not be low enough to admit of sufficient fall in the new portions. After the sewers are lengthened the increased volume to be carried may require more water-way than was formerly provided. The officers of the town are therefore driven to make alterations and additions from year to year, the duty of deciding what is best to be done often falling annually on different persons. They are guided by no definite plan, the endeavor commonly being to utilize as much as possible of the old constructions, and to incur the minumum of present expense.

When sewers are first built, either by private parties or by the town, it is not foreseen how desirable it will be to have their location recorded, and no data are filed away. Sometimes the only fact to be found, after some years and the constant change of officials, when all who were active in the matter at the time are out of reach, is that a sewer was built at a certain cost in a certain street. No definite plan, profile, location, or note as to size or material can be found. Sometimes the old drains and sewers are *discovered* when building new ones. Then the "oldest inhabitant" has some dim recollection of their existence; but for engineering facts his memory will not beforehand prove good.

As the need for extended drainage becomes more pressing, and as other matters in an engineering line call for the application of special talent, the city fathers begin to think that a city engineer, permanently employed, will be a desirable official. Heretofore an engineer may have been occasionally and temporarily hired; but it is manifestly more than can be expected of one employed for a short time to devise a system of sewerage, or, if planned, to get it carried out. He must manifestly do the best he can with the particular problem on hand.

As an instance of what results from the early endeavors to utilize the old when building new, we recall a case where, in one straight length, an oval brick sewer, 18 in. by 24 in. diameter, after coming down a steep hill, was joined to a stone sewer or culvert 3 ft. by 4 ft., rectangular, laid dry and constructed a number of years previous. At the lower end of this culvert the water again passed into an 18 in. by 24 in. oval brick sewer, which was added here when the wharf line was carried further into the stream than the mouth of the old culvert. Whenever a heavy fall of rain occurred the water, coming down the first portion in a torrent, laden with the washings from the street (as the gutter holes were not trapped), lost much of its velocity in the wider, stone portion, deposited the gravel, etc., and speedily choked up the entrance to the lowest and smaller part. Some cellars, close to this stone sewer, although not connected with it, as they drained in another quarter, were periodically flooded by the infiltration of back water.

We have also seen a place where an old wooden sewer, at the side of the street, had been renewed with brick at its lower end, prolonged at its upper end in the same way, and then being too shoal to drain cellars excavated later, had been replaced by a new one at a greater depth, in the centre of the street. The construction of the latter laid bare an almost unknown, because unrecorded, stone sewer in the lower portion of the street, constructed at a still earlier date. Those familiar with assessments for such work will see the difficulty of apportioning the expense satisfactorily.

From the same want of forethought and plan, cases occur where one sewer is theoretically discharging into another which turns out to be higher than the first. The failure of practice to agree with the theory generally soon calls attention to the trouble.

When a city engineer is appointed, it is manifestly his duty to bring the affairs of his department into system, to collate and record the old plans and such information of previous work as can be obtained. The amount is often scanty enough. If he endeavors to carry out a definite and comprehensive plan for drainage, and succeeds in getting the approval and support of the municipal officers for what he deems best (sometimes not an easy matter), he is still obliged to try to utilize sewers already laid. If this is not done, and even where it is done, another difficulty arises, in adjusting and collecting assessments.

Sewers are both a public and a private benefit. The cost of construction is usually defrayed, partly from the public treasury and partly by assessment on those directly benefitted, this class being considered to be the abuttors on that portion of the street in which the sewer is built. Besides the well known plea that they did not need a sewer, and that the present one is not so located as to benefit them, the landowners will claim that a smaller and less expensive one would answer as well for them, and that, if it was made larger to drain more territory, the more remote lots should pay for the increased cost. In cases where sewers have been laid before, they will urge that they have already been at the expense of a sewer; that, having paid for one, they expect the city to keep it in repair or renew it, and if, from extension elsewhere, this sewer has become too small, the cost of enlargement, or of a new sewer, should in no part fall upon them. There is often a good deal of truth in some of these arguments, but to reconcile conflicting interests and to forecast the best plan for future requirements are difficult tasks. Men who will readily put their names to a petition for a new sewer will, when it is built, devise most ingenious pretexts for getting clear of its assessments.

As a structure suitably devised and well built is the cheapest in the end, it follows that, if it were possible for a city goverment, at the very outset of the construction of sewers, to get a plan for their sizes, location and extension, adapted to the lay of the land, to the requirements of the future, and to the satisfactory disposal of their contents, the expense would be a minimum and the assessments could be made with a much better prospect of collection.

In the new and rapidly growing cities of the United States such a course can be adopted. The supervision of an engineer is needed, during the progress of the work, to ensure proper, accurate and durable construction.

THE LAND SURVEYOR.

Immediately after the close of the war of independence the illustrious statesmen of that age, foreseeing the inestimable value, present and prospective, to this Republic, of the national territory, and the importance of early opening the way for its settlement, and for a gradual and progressive transfer to individual ownership under well-defined principles, took measures for these ends, as shown by the journals of the Continental Congress, by reporting, on the 7th of May, 1784, "An ordinance for ascertaining the mode of locating and disposing of lands in the Western Territory."

That ordinance was considered, discussed, and amended until the expiration of a year from its introduction, when it was finally passed, May 7, 1785. It had no precedent in the theory or practice of any pre-existing government. It was the result not only of the highest order of statemanship, but exhibited a profound knowledge of engineering science in minute details.

Soon after the organization of the present government several of the States ceded to the United States large tracts of land, and these, together with the lands since acquired by treaty and purchase, constitute what is called the public lands, or public domain. Previous to the year 1802 these lands were parcelled out without reference to any general plan, in consequence of which the titles often conflicted with each other, and in many cases several grants covered the same premises.

The United States have never owned land in the New England States, the Middle States, or the Carolinas, Georgia, Maryland, Virginia, Tennessee, Kentucky, or Texas. In the New England and Middle States the land was granted in large tracts to individuals or companies by charters from England; e. g., the tract granted to William Penn in Pennsylvania, and the Van Rensselaer estate in New York.

If a man wanted to buy a few acres, or a few hundred acres of land, he went to the proprietors of these large tracts, and picked out just such a piece as he wanted, no matter how irregular the shape. If he wanted to take in a little corner of land containing a spring, or leave out another corner on which was a stony ridge or marsh, it was done. A surveyor was sent out to measure the tract, and the agent was paid so much an acre for it. If said surveyor was not a careful and accurate man, subsequent surveys have made those early farms overlap each other, or have left "gores" between them.

Colonel Jared Mansfield was the originator of our present rectangular system. We understand that he was employed by a company to survey and subdivide a large tract of land in Western New York, and, being a methodical man, he hit upon this method. We know that his ability as a surveyor attracted the attention of President Jefferson, by whom he was made Surveyor-General of the Northwestern Territory, and that the government adopted his method as *the method* for surveying the public lands. There is no system in the world which rivals it in simplicity and certainty of description. By it, with the use of a few figures and letters, you may describe ten acres anywhere among the Rocky Mountains, or farther west, so that a surveyor may start from Ohio and go to it with certainty, and without a guide, and without delay.

STATE LAWS.

As the men who make our laws do not know much about surveying, they make sad work in legislating on the subject. We think it the duty of surveyors to take hold of the matter of getting such State laws passed as shall be of some use to landholders and to surveyors, without conflicting with United States law. We have copies of the surveying laws for Iowa and Wisconsin, and will thank our readers if they will furnish us copies of the surveying laws in their respective States, that they

may be published in the NEWS, compared and commented on. Do you think it advisable to introduce such a bill as the following, and why, or why not?

An Act for the protection of landowners against the malpractice of imcompetent surveyors.

The people of the State of Wisconsin [or any other State], represented in Senate and Assembly, do enact as follows:

SECTION 1. That the Governor shall appoint a Board of Examiners, consisting of five members, each of whom shall be a practical surveyor, whose duty it shall be to meet at Madison on the tenth day of next August, and annually thereafter, and examine all applicants for a certificate of necessary qualification for the office of County Surveyor.

SEC. 2. Said Board of Examiners shall give a certificate of necessary qualificatiou—which shall be valid during the life of the recipient—to each applicant whom they shall deem properly qualified; and no man shall be eligible to the office of County Surveyor who is not in possession of such certificate; and any man who shall presume to practice surveying without such certificate shall be held guilty of a misdemeanor, and shall be subject to a fine of twenty-five dollars for each offense, and shall be deemed incompetent to testify in any court in regard to the surveying of any land. *Provided*, that nothing in this act shall interfere with present incumbents of the County Surveyor's office during their present terms.

Some Reasons for Asking Such an Act.=There is no question about the necessity for some authority to control the surveying of our land, because it is notorious that many incompetent men are acting as surveyors, and that their methods differ widely from each other, and from those authorized by United States laws and governmental instructions.

The man who has done nearly all the county surveying in this county during the past twenty years has pursued four different methods of subdividing any section not made fractional by a meandered body of water—e. g. section 10.

1. He has run the north and south quarter line, and taken the middle of it for the center of the section.

2. He has run the east and west quarter line, and taken the middle of it for the center of the section.

3. He has established the center as far from the north as from the south quarter post, and as far from the east as from the west quarter post, thus making both quarter lines crooked by his efforts to establish a geographical center.

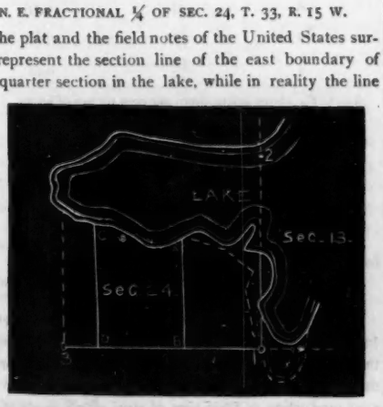
4. He has sometimes pursued the only correct method—i. e., has run a straight line between the north and south quarter poles, and another between the east and west quarter poles, and at the intersection of these two lines has established the center of the section.

He has rarely run more than one line through a quarter section before establishing its center. He has usually run a north and south line through the quarter section, or an east and west line, and taken the middle of the line for the center of the quarter.

The third method above mentioned has been placed on our statute book at two different times, at the instigation of a man who has a great reputation as a surveyor. He is a very accurate man, but at that time did not realize that Government had decided how a section should be subdivided. B. F. D.

N. E. FRACTIONAL ¼ OF SEC. 24, T. 33, R. 15 W.

The plat and the field notes of the United States survey represent the section line of the east boundary of this quarter section in the lake, while in reality the line



passes over a high bluff covered with heavy oak timber leaving 2¼ acres in section 13. The dotted lines from 1 to A represent the meander lines of the government survey, to define which on the ground would leave fully five acres of high tillable land to be considered as lake.

In striking the line for two separate forty acres of land per government survey, what should be considered the basis of operation?

1. Should the government survey be implicitly followed? or,

2. Should we follow the bold shore line?

3. May not section 24 rightfully claim the two acres in section 13 isolated as it is from the rest of the section, and the Notes not recognizing the same?

4. Should it (the two acres) so belong to section 24, then does it all fall to the adjacent forty acres, or should it be shared with the rest of the quarter section?

A full and definite answer to these questions would not only greatly oblige me, but a decision is watched with much interest by other parties more or less interested. The case occurred in my practice this last summer.

Very respectfully yours,

A. J. PIERCE.

[Answers are requested for publication in two weeks. ED.

We would call attention to the article in another column in reference to the instrument recently contrived by P. H. Dudley, C. E., of Cleveland, Ohio, for accurately determining the resistance of cars and engines under the conditions of actual use. We seem to have a good prospect of obtaining with the "Dynagraph" better formulæ for equating grades and curves than we have heretofore possessed. There are also many points in regard to railway equipment on which more light is needed, and for the solution of which Mr. Dudley is likelv to render much assistance The letters by Messrs. Evans and Latrobe in the *Railway Gazette* of last year, on this subject will interest engineers and railway men generally.

We desire to call the attention of our readers to the very carefully prepared article of G. W. Rafter, C. E., of Rochester, N. Y., which appears in our columns this week. Mr. Rafter has given the subject his careful study for some time, and has been assisted in his investigations by Dr. Stoddard, of Rochester, who prepared Table 1 from the records of the Health office of that city, and from the Sewerage reports of the City Surveyors office. Table 2 is from the advance sheets of the Health officer's report, and is probably very reliable.

The two articles on city sewerage which we publish this week are but the first of a series on the subject, which will be published from week to week in ENGINEERING NEWS, and we hope to enlist such talent in the preparation of our papers as will warrant us in assuring our readers that they will feel well repaid for their investment as subscribers for the present year. The subject is one of growing interest and popularity, and nothing can more forcibly illustrate this than the fact that so expensive a book as Baldwin Latham's Sanitary Engineering is all sold out and a new edition called for. We invite correspondence on the subject, and hope the City Engineer's of the country will respond.

The Architect and Civil Engineer.

The art of the Civil Engineer consists in selecting the best and most appropriate materials for the object he has in view, and using these in the most scientific manner, so as to insure an economical and satisfactory result. Where the engineer leaves off the art of the architect begins. His object is to arrange the materials of the engineer, not so much with regard to economical as to artistic effects, and by light and shade, and outline, to produce a form that in itself shall be permanently beautiful. He then adds ornament which, by its meaning, increases the effect of the disposition he has just made, and by its elegance throws a charm over the whole composition. Viewed in this light, it is evident that there are no objects that are usually delegated to the civil engineer which may not be brought within the province of the architect. A bridge, an aqueduct, the embankment of a lake, or the pier of a harbor, are all as legitimate subjects for architectural ornament as a temple or a palace. They were all so treated by the Romans and in the middle ages, and are so treated up to the present day in the remote parts of India, and wherever true art prevails. It is not necessary that the engineer should know anything of architecture, though it is certainly desirable he should do so; but, on the other hand, it is indispensably necessary that the architect should understand construction. Without that knowledge he cannot design; but it would be well if in most instances he could delegate the mechanical part of his task to the engineer, and so restrict himself entirely to the artistic arrangement and the ornamentation of his design. This division of labor is essential to success, and was always practiced when art was a reality; and no great work should be undertaken without the union of the two. Perfect artistic and mechanical skill can hardly be found combined in one person, but it is only by their joint assistance that a great work of architecture can be produced. A building may be said to be an object of architectural art in the proportion in which the artistic or ornamental purposes are allowed to prevail over the mechanical; and an object of engineering skill where the utilitarian exigencies of the design are allowed to supercede the artistic. But it is nowhere possible to draw the line sharply between the two, nor is it desirable to do so. Architecture can never descend too low, nor need it ever be afraid of ornamenting too mean objects; while, on the other hand, good engineering is absolutely indispensable to a satisfactory architectural effect of any class. The one is the prose, the other is the poetry of the art of building.—*Ferguson.*

Elevations above the Sea.

Having given some little attention during the past two years to determining the elevation of West Union, Fayette County, Iowa, above the sea level, we thought perhaps a few of the facts we have gathered during that period concerning elevations in northeastern Iowa, might be of some interest to our readers and so publish a table of elevations below. The data on which these determinations are based are all railroad surveys, and are probably as near the truth as it is possible to reach without more accurate levelings. The elevation of West Union is the mean of three nearly independent determinations differing from each other only five and a half feet.

The following elevations from the report of Mr. James T. Gardner, in Hayden's Report for 1873, have been used for the planes of reference in our determinations:

Cedar Rapids, R'y. grade at G. & N. W. depot,	741.15
Dubuque, Low Water in Mississippi river,	599.15
Lake Michigan, mean low water,	589.15

The elevations of the following stations are those determined during our investigations. The elevations are given in feet and tenths above the mean level of the sea.

West Union, water table Court House, (200 feet above city datum plane.)	1211.4
West Union, railroad grade at the depot	1116.7
Postville, " " "	1210.6
Clermont, " " "	872.7
Elgin, " " "	847.6
Brainard, " " "	926.5
Donnan " " "	1156.7
Randalia, " " "	1107.7
Maynard, " " "	1096.7
Oelwein, " " "	1049.7
McGregor, low water, Mississippi river,	615.9
Monona, railroad grade at the depot,	1257.7
Luana, " " "	1140.7
Ossian, " " "	1284.3
Calmer, " " "	1272.7
Decorah, " " "	899.5
Independence, Ill. Cent. R'y, grade at water tank,	924.0
Elkader, preliminary survey C. D. & M. Ry.,	744.0
Eldorado, " " "	946.0
Auburn, " " "	971.0
Low wator in Turkey river, at mouth,	609.0
Low water in Turkey river, at crossing of B. C. R. & C. Ry.,	818.7

The distance between the two last named points from careful measurement on the large maps of Clayton and Fayette counties is 60.6 miles, making the average fall for that portion of the river, 3.46 feet per mile.

We might greatly extend this list from data in the State Geological reports, but prefer to limit it for the present to those only which have been determined from data we have collected.

To the engineers who have so cheerfully answered our queries and thus greatly assisted us, we return our thanks. Although in some instances we have written many letters to the same person, in no case have we failed in receiving an early reply, with the information asked for if it was known. *Communicated*

The following formula will be found convenient for determining the proper thickness for the brickwork of sewers: $\frac{dr}{100}$ = thickness of brickwork.

d=depth of excavation.

r=external radius of sewer.

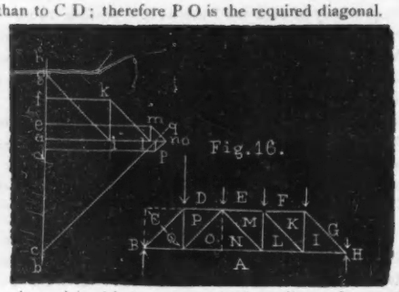
GRAPHICAL ANALYSIS OF ROOF TRUSSES.

BY CHAS. E. GREENE, A. M., PROF. OF CIVIL ENGINEERING, UNIVERSITY OF MICHIGAN.

VI.

Another truss with parallel chords may also be employed, in which the braces are alternately vertical and inclined. The designer will choose whether the verticals shall be ties and the diagonals struts, in which case the type is called the "Howe Truss," or the verticals struts and the diagonals ties, when the truss may be called the "Pratt," or perhaps the "Whipple." There is an advantage in having the struts as short as possible, but, if one desires to use but little iron, the "Howe" is a good form.

To decide which diagonal of the rectangle shall be occupied by the piece:—Start from the wall as a fixed point; it is evident that, to keep the load C D from sinking, C Q must be a strut. If we wish to put a tie in this panel, it must lie in the other diagonal, shown by the dotted line. C D now being held in place, P O as a strut will uphold D E. We thus work out from each wall until we reach the panel in which the whole load which acts on the truss might be considered to be concentrated, so far as its pressure on each wall is concerned. The position of the resultant of the load is called also its centre of gravity. If the resultant comes in the middle of a panel, no diagonal is required; if it divides the panel unequally, put in the diagonal which belongs to the larger segment. Thus for Fig. 16 it will be shown that the centre of gravity of the load is nearer to E D than to C D; therefore P O is the required diagonal.



As explained before, we might draw diagonals, one in each panel, sloping in either direction as we pleased, and then construct the stress diagram. If we found a stress on any diagonal, opposite to the stress we desired, we could then erase that diagonal and substitute the other, erasing also so much of the diagram as referred to the pieces of that panel.

It is easier, however, to find the position of the centre of gravity for the total load which affects the truss and incline all the braces similarly from each wall towards it. In the present example the load C D is supposed to be four times that on D E, etc. A tower on that end of the truss or some suspended load will account for the difference. If we recall the manner in which the supporting forces were determined when the load was unsymmetrical, we can see that, to find the position of the resultant of the separate loads, so that, if the total load were at that point, the supporting forces would still be the same as the aggregate for each load by itself, we must multiply each load by its horizontal distance from some convenient point, for instance a point of support, and divide the sum of these products by the total load; the quotient will be the desired distance of the resultant from the same point. As the panels are all equal, a panel may be taken as a unit of distance; call a panel length p, and the ordinary weight on a joint, w. Then we shall have, taking moments about H,

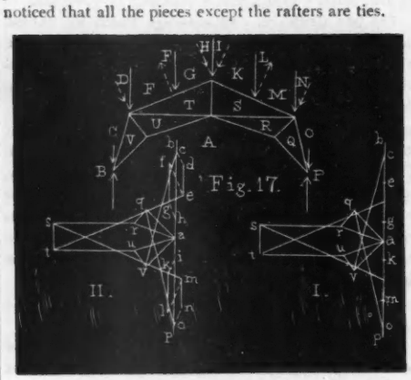
$$\frac{w.p\ (1+2+3)+4\ w.4p}{7\ w} = 3\tfrac{1}{7} \text{ panels},$$

the distance of the resultant from the end H. The loads directly supported at the walls do not affect the truss.

If the resultant divides the truss in the proportion of $3\frac{1}{7}$ panels to $1\frac{6}{7}$ panels, the two supporting forces, excluding the amounts to balance B C and G H, will be in the same proportion, the larger force being on the side of the shorter division. Therefore, drawing the load line $b\,h$, and measuring off $b\,c$ and $g\,h$, divide $c\,g$ at a into $\frac{22}{35}$ and $\frac{13}{35}$. The two supporting forces wil then be $b\,a$ and $a\,h$. Draw the stress diagram as usual; the diagonals will all come in compression as intended. There will plainly be no stress in the dotted vertical O N. The stress on the chords being inversely proportional to the depth of the truss, economy of material in the chords will be served by making the depth as much as possible. In bridge trusses this depth is seldom less than one-eighth of the span.

If the joint D E also was heavily loaded, we could draw another diagram for that case, and, as the joints in succession had their loads increased, we might make as many diagrams. From a collection of diagrams for all positions of a moving load, we could select the maximum stress on each piece, A truss designed to resist such stresses would then answer for a bridge. We should find that the greatest stresses in the chords occurred at all points when the bridge was heavily loaded throughout, and that the greatest stress in a diagonal occurred when the bridge was heavily loaded from this piece to one end only, that end generally being the more distant one. As we have more expeditious methods of treating a bridge truss, this one is not used. The reader who is interested in the graphical treatment of such a subject can find it explained in "Graphical Analysis of Bridge Trusses." *

We have heretofore treated all the trusses as if the loads were concentrated at those points only which were directly supported. It not seldom happens that the cross-beams or purlins, which connect the trusses and convey the weight from the secondary rafters to the main rafters, rest at points intermediate between the joints. Let us in the present examples, Fig. 17, assume that a load rests upon the middle of each of the upper rafters, If we pursue the previous method (leavtng out of account, for the present, the bending action of this load), one half of the load E G will be supported at each of the joints C E and G K, and similarly for the load K M. Therefore, having laid off the weights and the two equal reactions of the walls on the load line of the first diagram, we may increase the loads on the joints C E, G K and M O, by the new points of division, and complete this diagram, taking first B, then the next joint on the inside, and then the outside one. It will be noticed that all the pieces except the rafters are ties.



This diagram gives but one stress along the whole of the upper rafter; but it is plain that the vertical load E G must have a component along the rafter which will cause a different stress to exist on E T to what exists on G T. If, however, we suppose a joint at E G, the transverse component will cause it to yield, as there is no brace under it to hold it in place. Let us supply an imaginary force E F, shown by the dotted line, equal and directly opposed to this transverse component, which will take the place of a perpendicular strut, will steady the joint, and will leave the longitudinal component to affect the rafter. But the transverse component of F G actually gives a pressure at the joints C E and G K, while the imaginary force E F, just added, will lift the ends of this rafter to the same amount; therefore we must restore the pressure by adding imaginary forces, each one half of E F, at C D and G H. This added system of forces cannot intefere with the stresses in any other pieces, for they balance by themselves. Treat the similar load K M in the same way.

Draw now, for the second diagram, $p\,a$ and $a\,b$, the two supporting forces, each equal to one half the total load. Then lay off $b\,c$, as before; draw the dotted line $c\,d$, equal and parallel to the first imaginary force C D, then $d\,e$, vertical as before, then $e\,f$, equal and in the direction of E F, then $f\,g$, and so on, arriving finally at p, as usual.

The construction of the rest of the diagram presents no difficulty; the joints are taken in the same order as before, and, when we have more than one external foree on a joint, we take them in succession, passing in the order first observed for the external forces. When we reach the upper rafters, it will be noticed that g falls on the line $e\,t$; $e\,t$ will be seen to be greater and $g\,t$ less than the corresponding line in the other figure. The first diagram gives the stress which would exist in the whole length of the rafter E T G if the load F G were actually at its extremities; but, being at its middle point, one half of the longitudinal component of F G goes to diminish the compression otherwise existing in G T, and the other half to increase the compression in E T.

A comparison of the two diagrams will show the truth of the former statement, that the system of imaginary forces does not affect any of the truss outside of the particular pieces to which it may be applied. It is still necessary to provide for the bending action of the transverse portion of F G, or a force equal and opposite to E F, upon the rafter, considered as a beam extending from hip to apex, a joint of course not being made at E G. This subject will be taken up later.

The treatment of loads or of forces not directly resisted, as above, is given by Mr. Bow, in his "Economics of Construction," and may be applied to frames where one or more of the internal spaces are not triangles, but quadrilaterals; the truss would then be liable to distortion, unless the resistance of some of the pieces to bending or the stiffness of the *theoretical* joints was called into play. A too frequent use of this treatment in the same diagram will, however, be apt to make confusion.

Entered according to Act of Congress, in the year 1875, by Charles E. Greene, in the Office of the Librarian of Congress, Washington.

* Graphical Method for the Analysis of Bridge Trusses, extended to Continuous Girders and Draw Spans, by C. E. Greene; New York, D. Van Nostrand, 1875.

Cost of Cast Iron Water Pipe, in Place.

The following data from a contract for Water Works made and completed the last season may be of interest to engineers when making up an estimate.

The pipe is to be of cast iron, from two to sixteen inches internal diameter, thickness as below, socket joints of standard lengths, packed with hemp or yarn, then filled with melted lead and carefully and securely caulked Pipe to be measured for payment after they are laid in the ground. Trench to be six feet deep, to be excavated, back filled, and street to be restored to its former condition. The streets are not paved, but cross walks are re-laid, and sewers made good if broken. All pipes to be tested by the manufacturer, with an hydrostatic pressure of 300 pounds on the square inch, and the entire system when laid, pipes, hydrants, and gates, to be subjected to a pressure of 200 pounds on the square inch, as shown by the guage at the pump house.

The sizes, the thickness, and price per lineal foot for each dimension of pipe when laid, covering all excavation, filling, etc., are,

Internal Diameter.	Thickness.	Price per foot.
16 in.	$\frac{3}{4}$ in.	$3.57
12	$\frac{5}{8}$	2.27
8	$\frac{55}{100}$	1.40
6	$\frac{1}{2}$	1.04½
4	$\frac{7}{16}$	0.72
2	$\frac{35}{100}$	0.42

Add to the above prices three per cent for lap of joints.

For each hydrant set	-	-	$55 00
" 16 in. gate and cover set			195 00
" 12 " "			110 00
" 8 " "			61 00
" 6 " "			44 00
" 4 " "			30 00

All to be boxed with two inch pine plank.

Ledge or solid rock of more than 20 feet in length to be an extra charge.

The pipes were transported some 600 miles by water.

The Steel works of Messrs. Park, Brothers & Co., Pittsburgh, cover seven acres of territory. They employ three hundred men, paying twenty thousand dollars on their monthly pay roll. The works are equal to an annual production of 7500 tons of steel of all descriptions, for which they find a market in all quarters of the United States, with occasional consignments to Europe.

Astronomical Notes.—No. XI.

PREPARED FOR ENGINEERING NEWS BY S. W. BURNHAM, F. R. A. S.

A fine 12-inch refracting telescope has lately been put up for Prof. Pritchell at Glasgow, Mo., by Messrs. Alvan Clark & Sons. It is provided with all the accessories of a first class instrument, and has an object glass of unusual excellence. Some interesting double star discoveries were made with it by Mr. Alvan G. Clark before leaving home. It has not been stated to what particular department this glass will be directed, but the possessor of such an aperture would rarely wish for a larger, for any purpose.

The Lalsnde prize in Astronomy has been awarded by the French Academy to Perrotin, of the Toulouse Observatory, for his astronomical work generally, and specially for his discoveries of small planets.

Dr. Schmidt, Director of the Observatory of Athens, has issued the results of his observations of the great comet of 1874, from May 3d to July 23d, when it was seen for the last time. The observations refer to the brightness of the nucleus in the telescope, and the head of the comet as seen with the naked eye, and the apparent length of the tail. Taking the distance of the comet from the earth by the best computed orbits, the mean diameter of the nucleus was about 290 miles.

The last number of the *Astronomische Nachrichten* contains a catalogue of prominent stars, many of them being near the pole, the Right Ascensions of which have been carefully determined at the Harvard College Observatory. The observations were made during the years 1872–3 under the superintendence of the late Prof. Winlock. The observatory is now in charge of Prof. Searle, the new director not yet having been appointed.

Lockyer, the English astronomer, has in press a work on the "Modern Telescope." As both refractors and reflectors have been much improved in the last few years, and many new conveniences added to the working part of the instrument, such a work cannot fail to be valuable and interesting. The only book devoted entirely to this subject is Sir John Herschel's "The Telescope" which originally formed a contribution to the *Encyclopedia Britanica*. At that time the largest refractor in the world was only fifteen inches, while at the present time there are several exceeding two feet, necessitating great changes and improvements in the mounting tube, driving apparatus and many minor details.

At the December meeting of the *Royal Astronomical Society* Mr. Ranyard read a paper on the duplicate structure of Coggia's comet of 1874, showing that during the early part of July the comet was seen to be a twin structure,—though there was but one nucleus,—there were two sets of parabolic envelopes situated side by side and overlapping, so that the nucleus seemed to be placed at the intersection of the two inner arcs.

This structure was drawn by several observers, and later in the month Mrs. Newall, at Gateshead, and Mr. With of Hereford, each made drawings which showed two faint parabolic arcs still further in front of the nucleus, and separated laterally by a much greater interval than the former arcs. He thought that this showed there was a disruptive action going on within the comet as it approached perihelion, similar to the disruption which took place in Biela's comet of 1846.

At the close of November the St. Gothard tunnel had been pierced a depth of three miles 1944 feet.

The directors of the Hocking Valley Railroad declared a semi-annual dividend of 4 per cent. The gross earnings of the road for the year were over $900,000; over $130,000 were expended in relaying track with steel rails, and it is estimated that a like amount for the same purpose will be required the coming year.

Civil Engineers' Club of the Northwest.

Minutes of the January Meeting, 1876.

The 62nd regular meeting was held at the Sherman House Club Rooms on the 4th of January 1876, beginning at 4:30 P. M.

In the absence of the President Col. R. B. Mason was called to the chair.

The minutes of the December meeting were read and approved.

(President Chesbrough took the chair).

The following names were proposed for membership: John A. Cole, by Messrs. E. S. Chesbrough and B. Williams; John Nichol, by Messrs. E. S. Chesbrough and W. S. McHarg; Edward A. Fox, by Messrs. S. S. Greeley and G. H. Frost.

Upon ballot E. B. Noyes was elected a member.

Mr. F. W. Clarke read the paper for the evening, No. 57, "BELT RAILROAD PROJECTS ABOUT CHICAGO," which was followed by the usual discussion.

Mr. Greeley, of the Executive Committee, reported that the Library Committee, upon consideration, advised that no purchase of books be made at present, and that the dues collected for that purpose be refunded to the members who had paid them.

The Secretary, a member of the same committee, spoke upon the report and offered the following resolution, which was adopted:

Resolved, That the resolution appropriating the sum of $200 from the dues to be collected for the present fiscal year be reconsidered.

The Secretary submitted the following:

Resolved, That the collection of dues for the present year be suspended until further action by the Club, and that the dues already collected be refunded to the members who have paid them.

The resolution was adopted.

Mr. Greeley was appointed a committee to report at the next meeting upon the subject of a permanent committee to whom nominations shall be referred.

The Executive Committee were directed to report upon the propriety of collecting the different papers read before the Club and publishing them in one volume.

The meeting adjourned.

L. P. MOREHOUSE, *Secretary*.

SELECTED LIST OF PATENTS

For the week ending January 7th, 1876.

Relating to Mining, Metallurgy, Engineering, &c., reported for ENGINEERING NEWS by Louis Bagger & Co., Solicitors of Patents, Washington, D. C.

171,470. Mining Machines. A. Crombie, Wilmington, Ill.

In this machine the cutting wheel rests on a step in the body of the main frame, on which it revolves by means of suitable gearing, and having in combination with it the dust shield.

171,493. Machine for dressing the heads and pointing and threading the shanks of bolts. Wm. E. Ward, Portchester, N. Y.

A vibrating holder for receiving the blank from the railway guide, and a follower rod for pushing said blank out of the holder through a spring scroll guide (which rotates it axially, so as to insure the proper position of the squared portion under the head), and into the revolving gripping-jaws. Mechanism for closing said jaws upon the blank, and mechanism for automatically operating the holder which carries the pointing and threading dies, so as to bring each of said dies into coincidence with the axis of the same at the proper time. A vibratory laterally-yielding gage causes the head of the blank to project sufficiently to allow the shaving tool to operate upon it. The finished bolt is discharged from the machine by a rod which works through the hollow spindle of the die-holder.

171,563. Petroleum Wells. Wallace L. Hardison, St. Petersburg, Pa.

This invention consists in the combination of a pumping tube, a tube through which steam is admitted to the lower part of the well, a tube through which gas and steam may escape from the well, and a packer surrounding these tubes.

171,594. Spark Arrester. D. Allard, St. Albans, Vt.

The V-shaped ring attached to the lower end of the adjustable tube prevents exhaust steam and sparks in their ascent from entering the annular space between said pipe and the casing, and in the descent of the sparks in said annular space directs them upward through the inn r pipe.

171,597. Gold Washers. John S. Calvert, Denver, Col.

The usual sluice-box is provided with wings to deflect the current and suspended gold through the riffle-bars.

171,599. Anti-incrustation Compounds. Auguste Chavasse, Montreal, Canada.

A combustion for removing boiler-scale of molasses of sugar, extract of cedar bark, and the whites of eggs, prepared and mixed.

171,607. Gas Machines. T. B. Fogarty, New York, N. Y.

The hydrocarbon oil is forced by air pressure into the retort, where it is vaporized. The vapor, under pressure, escapes by the nozzle of an injector valve, and induces a current of air, which mixes with it, and the product passes to the holder. The injection valve is operated by a novel system of weighted levers, having cams and projections which permit their cojoined and consecutive operation. One of them is connected by a rod to a weighted horizontal bar, and this by a rod to the rising and falling gas-holder. Below the holder a carburetting drip-box is placed, provided with a float and valve. This box catches any condensed vapors, and, by forcing air through it, the first gas is here generated for supplying the burners under the retort to start the machine. The retorts and burners are inclosed in an air-tight can, supplied with air through a pipe leading from the outside of the building.

171,655. Petroleum Wells. W. L. Hardison, St. Petersburg, Pa.

The stem pipe and protecting tube are supported upon the pumping tube by the device seen, said device having a guide flange for the insertion of the protecting tube and stem pipe. The heat from the steam is confined below the packer, as the water above it would condense any that might pass up the tube. The steam pipe can be withdrawn without disturbing the packer.

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Extract from report of Committee of Civ. Engs. appointed by Franklin Inst. to examine H. & B.'s new Transit (Dec. 1871): "It exhibits several novelties of construction which, in the opinion of the committee, render it superior to those now in use, and in its opinion the deviations which they have made from the common styles of Transit are decided improvements."
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